

as  
g is a gravitational acceleration ( $\text{m/sec}^2$ ), and  
 $\sigma$  is a surface tension of seawater ( $\text{kg/sec}^2$ )  
in the case of using a perforated or grid plate column without weir and  
downcomer composed of at least one perforated plate and the ratio  $\rho_G/\rho_L$  of the density  
 $\rho_G$  ( $\text{kg/m}^3$ ) of the treated gas to the density  $\rho_L$  ( $\text{kg/M}^3$ ) of seawater is at least  
 $0.838 \times 10^{-3}$ .

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A marked up copy of the amended material from the specification and the claims  
as amended are attached hereto as required by 37 C.F.R. §1.121.

### REMARKS

The Office Action dated April 9, 2002 has been received and carefully noted.  
The above amendments to the claims, specification and the following remarks are  
submitted as a full and complete response thereto. Claims 1 and 2 have been  
amended. In addition, claims 3 and 4 have been added. No new matter has been  
added or amendments made which narrow the scope of any elements of any claims.  
Accordingly, Claims 1-4 are pending in this application and are submitted for  
consideration.

Regarding the drawings, Applicant has amended the description of drawings 3  
and 4 in order to distinguish these drawings. Figures 3 and 4 are distinguishable since  
figure 3 shows one perforated plate in the column while Figure 4 shows 2 perforated  
plates. The description of the drawings have been amended to make this distinction. In  
addition, Applicant respectfully notes that Figures 2, 3, and 4 are not prior art, but  
rather, as explained in the specification, are the systems according to the present  
invention.

Claims 1 and 2 were objected to in the Office Action. To overcome the objection, Applicant has amended claims 1 and 2 as suggested in the Office Action. Applicant believes the objections has now been adequately addressed.

Claims 1 and 2 were rejected under 35 U.S.C. § 112 on the grounds that the phrases "noncontact seawater," "of 1030," "Ugm," and "exhaust gas." rendered the claims indefinite. Amended Claims 1 and 2 overcome these rejections. Claim 1 was also rejected under 35 U.S.C. § 112 on the grounds that there was no antecedent basis for the seawater being subjected to mixing. Claim 1 has been amended to correct the same. Amended Claim 2 overcomes this rejection as well.

Claims 1 and 2 were rejected under 35 U.S.C. § 103(a) as being unpatentable over JP 11-290,643, in view of pages 14-13 and 18-31 in the Chemical Engineers Handbook (5th Ed.) edited by Perry et. al. The Examiner admitted that the present invention uses a packed column while JP-643 uses a plate column, and that the packing height in the tower ranges from 0.5 to 4 meters. To make up for this deficiency, the Examiner cites page 14-13 in the Chemical Engineer's Handbook for the proposition that the packed columns offer an economic advantage for small columns where the diameter of the column is less than 2 feet. Therefore, it was asserted that it would have been obvious to one skilled in the art to modify the process in JP-643 by substituting a packed column for a plate column in order to arrive at the present invention. Applicant respectfully, but most strenuously, traverses this rejection.

Unlike the prior art, the present invention teaches use of a gas-liquid contact apparatus composed of an absorption column provided internally with a perforated plate packed with at least one type of fillers. More specifically, the present invention recites

an absorption column having a column diameter of at least 500 mm, provided with a perforated plate having a free-space ratio  $F_c$  of 0.25 to 0.5 and packing material with a packing height of 0.5 m to 4 m. Seawater is used as a gas absorbing liquid which is oxidized with air in the gas-liquid contact apparatus, followed by the addition of raw seawater.

The result of the present invention is that the exhaust gas containing an acidic component (such as  $\text{SO}_2$ ) can be effectively treated with seawater, and the resultant waste seawater can be discharged into sea only by the oxidation with air and the mixing with raw seawater. This is neither taught nor suggested by the prior art references and is therefore not obvious.

In JP-643, the exhaust gas containing the acidic component is passed through a gas-liquid contact apparatus and contacted with seawater. However, the gas liquid contact apparatus is a plate column, not a packed column. The contact seawater is then treated with sodium hydroxide ( $\text{NaOH}$ ), oxidized, and released to the sea. JP-643 does not teach that contact seawater can be discharged back to sea without using chemicals such as  $\text{NaOH}$ .

In addition, JP-643 does not disclose the second contact with raw seawater after oxidation. This is a prime feature of the present invention and is an improvement over JP-643. The object of the present invention is to remove the acidic component from the seawater without additional chemicals. The addition of the extra seawater step accomplishes this without any extra chemicals such as the addition of sodium hydroxide ( $\text{NaOH}$ ). This point was not taught by JP-643.

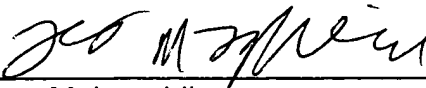
Further, the Chemical Engineer's Handbook does not teach use of a perforated plate and packed column as disclosed in the present invention. It appears that there was confusion in the Office Action regarding diameter and packing height. The present invention does not address a diameter range for the column, but states that the packing height may be in a range 1.5 to 4 meters. Thus, the reference teaching as to the economics of tower design would not necessarily suggest that the packed tower would be economical for the invention as claimed. As such, there is no suggestion in the art to use the Chemical Engineers Handbook to modify the primary reference to arrive at the present invention. Consequently, the present invention would not have been obvious to one of ordinary skill in the art.

In view of the above remarks, the Applicant respectfully submits that each of Claims 1-4 recite subject matter which is neither disclosed nor suggested in the cited prior art. Applicant submits that this subject matter is more than sufficient to render the claimed invention unobvious to a person of ordinary skill in the art. Applicant therefore requests that each of the pending claims be found allowable, and this application be passed to issue.

If for any reason the Examiner determines that the application is not now in condition for allowance, it is respectfully requested that the Examiner contact, by telephone, the Applicant's undersigned attorney at the indicated telephone number to arrange for an interview to expedite the disposition of this application.

In the event this paper is not timely filed, the Applicant respectfully petitions for an appropriate extension of time. Any fees for such an extension together with any additional fees may be charged to Counsel's Deposit Account No. 01-2300.

Respectfully submitted,

  
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## **MARKED-UP COPY OF SPECIFICATION AND CLAIMS**

### **IN THE SPECIFICATION**

Title of the Invention:

PROCESS FOR [FOR ADVANCED TREATMENT FOR]  
DESULFURIZATION OF EXHAUST GAS WITH SEAWATER

Page 4, line 29:

Fig. 3 is an example of an absorption apparatus consisting of [a combination of] a perforated or grid plate without weir and downcomer and a packed column in the case of treating boiler exhaust gas by the method according to the present invention.

Page 4, line 34:

Fig. 4 is an [another] example of an absorption apparatus consisting of a combination of two perforated or grid plates without weir and downcomer and a packed column in the case of treating boiler exhaust gas by the method according to the present invention.

Page 6, line 32:

As explained above, the present invention successfully uses a gas-liquid contact apparatus equipped inside thereof with an absorption column containing at least one perforated plate and at least one type of packing materials with a packing height of at least 0.5 m, preferably 0.5 m to 4 m (e.g., RASCHIG™ [Raschig]rings, pole rings, Terralets, interlock saddles, etc.) and introduces seawater from the top of the gas-liquid

contact apparatus or introduces seawater from the top of the gas-liquid contact apparatus so as to cause countercurrent gas liquid contact with the gas to be treated and to use the alkali in the seawater to effectively and advancely remove the sulfur oxides contained in the exhaust gas.

Replace the paragraph beginning on page 7, line 8 with:

Note that the technology for treatment of an exhaust gas using a perforated plate or grid plate column without weir and downcomer (i.e. “MORETANA™[Moretana]” column) is disclosed in Japanese Examined Patent Publication (Kokoku) No. 5131036 and Japanese Examined Patent Publication (Kokoku) No. 60-18208 (or U.S. Patent Nos. 3892837 and 3941572) but the present inventors found that the operating regions A and B (see Fig. 1) already shown there is not suited for the treatment of exhaust gas utilizing seawater. The above-mentioned JP-A-11-290643 proposed the need for the ratio L/G of the flow rate of gas G supplied to the column and the flow rate L of seawater to be at least 3.6, preferably 7 to 25, and for the superficial gas velocity  $U_g$  passing through the “MORETANA™[Moretana]” column and the flow rate L of the treatment liquid to be the relation in the region C of Fig. 1, that is, in the range from more than  $3.43 L^{-0.0807} \cdot U_{gm}$  (m/sec) to 8 (m/sec) where  $U_{gm}$  is the maximum permitted superficial gas velocity. However, the outside of this range, particularly when  $U_g$  is too low, there is the problem that the efficiency of gas-liquid contact drastically falls and it becomes impossible to remove the acidic component. However, according to the present invention, by utilizing an absorption apparatus composed of a combination of a “MORETANA™[Moretana]” column and a packing column, the desired gas-liquid

absorption is effectively performed even in the region D of Fig. 1 and the highly efficient desulfurization treatment becomes possible.

Replace the paragraph beginning on page 10, line 16 with:

As explained above, according to the present invention, it is possible to advancely and effectively treat the sulfur oxides contained in an exhaust gas with seawater, despite the region being unable to be treated by "MORETANA™[Moretana]" column in the past, that is, a low Ug, and possible to protect the environment simply and with a compact equipment and low cost.

Replace the abstract beginning on page 13 as follows:

PROCESS FOR [FOR ADVANCED TREATMENT FOR]

DESULFURIZATION OF EXHAUST GAS WITH SEAWATER

A method for removing an acidic component such as <sup>SO<sub>2</sub></sup> sulfite gas (SO<sub>2</sub>) contained in an exhaust gas comprising by using a system comprising (a) a gas-liquid contact apparatus composed of an absorption column provided internally with at least one perforated plate at the top, bottom, or both top and bottom of the absorption column packed with at least one type of fillers, (b) an apparatus for introducing raw seawater to the absorption column, (c) an apparatus for oxidizing the seawater after gas-liquid contact, and (d) an apparatus for mixing raw [a noncontact] seawater with the contact seawater <sup>that has been oxidized</sup> after [subjected to the mixing] oxidation, whereby the exhaust gas containing an acidic component is brought into gas-liquid contact with the seawater.



## CLAIMS

1. (Amended) A method for removing an acidic component contained in an exhaust gas comprising:

(a) introducing raw seawater into a gas-liquid contact apparatus composed of an absorption column provided internally with at least one perforated plate at the top, bottom, or both top and bottom of the absorption column packed with at least one type of fillers to thereby effect an exhaust gas-seawater counter current contact treatment,

(b) oxidizing the seawater after the gas-liquid contact with air in an oxidation apparatus[an apparatus for introducing seawater to the absorption column],  
and

(c) mixing raw seawater with the seawater after the oxidation, whereby the exhaust gas and the oxidized seawater are discharged.[ an apparatus for oxidizing the seawater after gas-liquid contact, and (d) an apparatus for mixing a noncontact seawater with the seawater after subjected to the mixing and oxidation, whereby the exhaust gas containing an acidic component is brought into gas-liquid contact with the seawater.]

2. (Amended) A [wet] method as claimed in claim 1, whereby the seawater is introduced into [for removing an acidic component contained in an exhaust gas, in] a gas-liquid contact apparatus including an absorption column having a column diameter of at least 500 mm and provided with at least one perforated plate having an free-space ratio  $F_c$  of 0.25 to 0.5 and packed [provided] with at least one type of packing material to [with] a packing height of 0.5 m to 4 m, [comprising supplying seawater] in such an

amount that a ratio  $L/G$  of the flow rate  $L$  ( $\text{kg/m}^2\cdot\text{hr}$ ) of the seawater to the flow rate  $G$  ( $\text{kg/m}^2\cdot\text{hr}$ ) of the gas to be treated from the top of the column is at least 3.6 and a flow rate  $L$  of the seawater is  $1 \times 10^4$  to  $25 \times 10^4 \text{ kg/M}^2\cdot\text{hr}$  and introducing a treated gas in such an amount that a range of a superficial gas velocity  $U_g$  in the apparatus from the bottom of the gas-liquid contact apparatus is less than  $2 U_{gm}$  [0 to  $2 \cdot U_{gm}$ ] ( $\text{m/sec}$ ):

in the case of using a perforated or grid plate column without weir and downcomer composed of at least one perforated plate and the ratio  $\rho_G/\rho_L$  of the density  $\rho_G$  ( $\text{kg/m}^3$ ) of the treated gas to the density  $\rho_L$  ( $\text{kg/m}^3$ ) of seawater [of 1030] is at least  $0.838 \times 10^{-3}$

$$U_{gm} = 49.14 \text{ } Fc^{0.7} (\rho_G/\rho_L \times 10^{-3})^{-0.5} \cdot (L/G)^{-1/3} \cdot \sqrt{g \cdot L}$$

wherein  $L$  is a capillary constant  $\sqrt{2\sigma/\rho_L \cdot g}$ ,

$g$  is a gravitational acceleration ( $\text{m/sec}^2$ ), and

$\sigma$  is a surface tension of seawater ( $\text{kg/sec}^2$ )[whereby the gas to be treated and seawater are countercurrently brought into gas-liquid contact].

3. An apparatus for removing an acidic component contained in an exhaust has comprising:

(a) a gas-liquid contact apparatus composed of an absorption column provided internally with at least one perforated plate at the top, bottom, or both top and bottom of the absorption column packed with at least one type of fillers, in which the exhaust gas is contacted with seawater,

(b) an apparatus for oxidizing seawater after the gas-liquid contact with air, and

(c) an apparatus for mixing raw seawater with the seawater after the oxidation.

4. An apparatus as claimed in claim 3, wherein the gas-liquid contact apparatus comprises an absorption column having a column diameter of at least 500 mm, which is provided with at least one perforated plate having a free-space ratio  $F_c$  of 0.25 to 0.5 and provided with at least one type of packing material with a packing height of 0.5 m to 4 m, in which the seawater is introduced in such an amount that a ratio  $L/G$  of the flow rate  $L$  ( $\text{kg}/\text{m}^2 \cdot \text{hr}$ ) of the seawater to the flow rate  $G$  ( $\text{kg}/\text{m}^2 \cdot \text{hr}$ ) of the gas to be treated from the top of the column is at least 3.6 and a flow rate  $L$  of the seawater is  $1 \times 10^4$  to  $25 \times 10^4 \text{ kg}/\text{M}^2 \cdot \text{hr}$  and introducing a treated gas in such an amount that a range of a superficial gas velocity  $U_g$  in the apparatus from the bottom of the gas-liquid contact apparatus is 0 to  $2 \cdot U_{gm}$  (m/sec):

$$U_{gm} = 49.14 \cdot F_c^{0.7} \cdot \left( \rho_G / \rho_L \times 10^{-3} \right)^{-0.5} \cdot (L/G)^{-1.3} \cdot \sqrt{g \cdot L}$$

wherein  $L$  is a capillary constant  $\sqrt{2\sigma/\rho_L \cdot g}$ ,

$g$  is a gravitational acceleration ( $\text{m}/\text{sec}^2$ ), and

$\sigma$  is a surface tension of seawater ( $\text{kg}/\text{sec}^2$ )

in the case of using a perforated or grid plate column without weir and downcomer composed of at least one perforated plate and the ratio  $\rho_G/\rho_L$  of the density  $\rho_G$  ( $\text{kg}/\text{m}^3$ ) of the treated gas to the density  $\rho_L$  ( $\text{kg}/\text{M}^3$ ) of seawater is at least

$0.838 \times 10^{-3}$ .